The global energy landscape is evolving towards decentralization and reliance on renewable sources. This rapid adoption underscores the need for energy storage and security of supply to ensure stability amid rising demand. Thermal power plants can provide this flexibility within the future energy mix. Micro Gas Turbines (mGTs) are emerging as a potential technology for small-scale Combined Heat and Power (CHP) applications due to their compact design, high power-to-weight ratio, and ability to use various fuels.

While mGTs have historically lagged behind reciprocating Internal Combustion Engines (ICEs) in small-scale CHP, their potential in decentralized and hybrid power systems offers significant benefits, including improved efficiency and reduced emissions. Despite higher costs and lower transient response compared to ICEs, mGTs' advantages in flexibility and modularity make them suitable for future energy systems. However, more research is needed to ensure that mGTs are suitable for small-scale CHP and can effectively compete with ICEs. The objective of this work is to answer the following question:

"Can mGTs increase their performance and contribute to future energy"

This thesis aims to enhance mGT performance through advanced humidification techniques and operational optimization. The research involves developing and validating modelling methods for both conventional and 2-spool intercooled mGTs. Specific focus is given on optimizing water injection strategies to boost efficiency and waste heat recovery. Various fuel mixtures and operational strategies are evaluated. Advanced humidified cycle concepts are tested and various conditions are considered to adopt a humidified configuration for the two-stage mGT.

The results indicate that the micro Humid Air Turbine (mHAT) cycle achieves the highest electrical efficiency and notable fuel consumption reduction considering the adoption of three heat exchangers for the system, making it suitable for scenarios with low heat demand. A techno-economic analysis further highlights the potential of mGT configurations in hybrid renewable energy systems, demonstrating their cost-effectiveness and efficiency across different applications. In conclusion, this thesis provides insights into optimizing mGT configurations, emphasizing their role in sustainable and efficient power generation. The findings support the integration of mGT technology into decentralized energy systems, aiding the transition towards a more sustainable energy landscape.